National Aeronautics and Space Administration

UAS Integration in the NAS Project

Integrated Test and LVC Infrastructure

Ty Hoang and Jim Murphy: Integrated Test and Evaluation

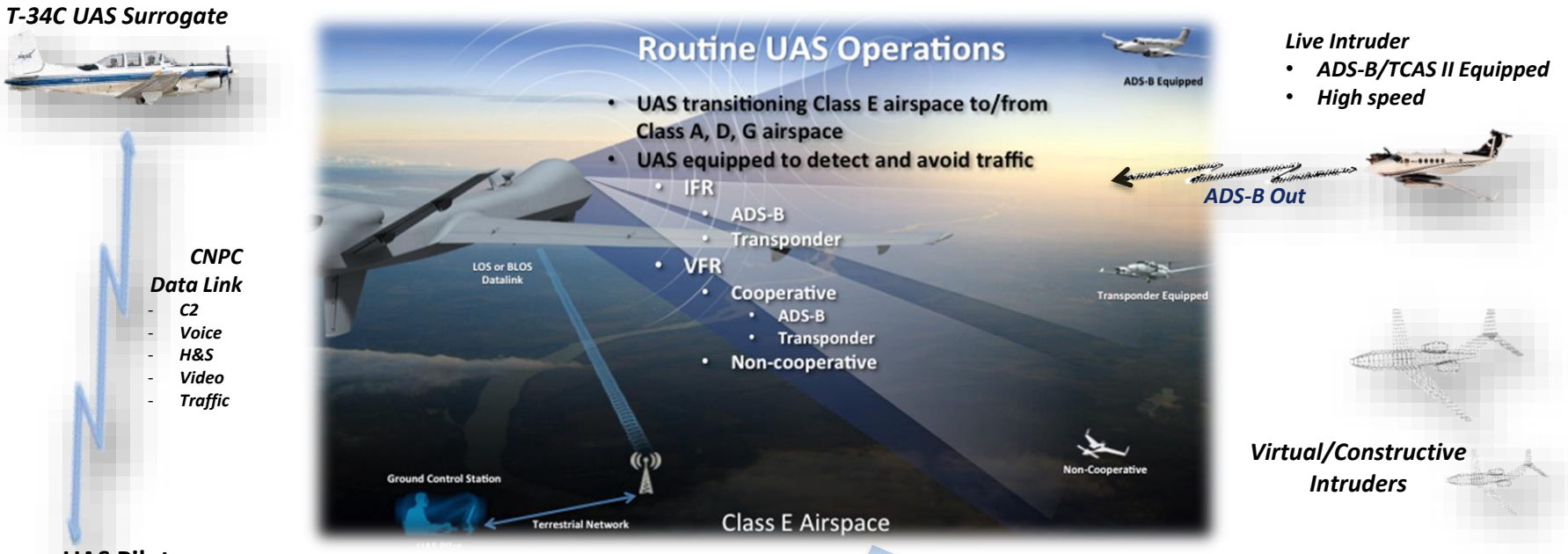
June 18, 2015

LVC Connection

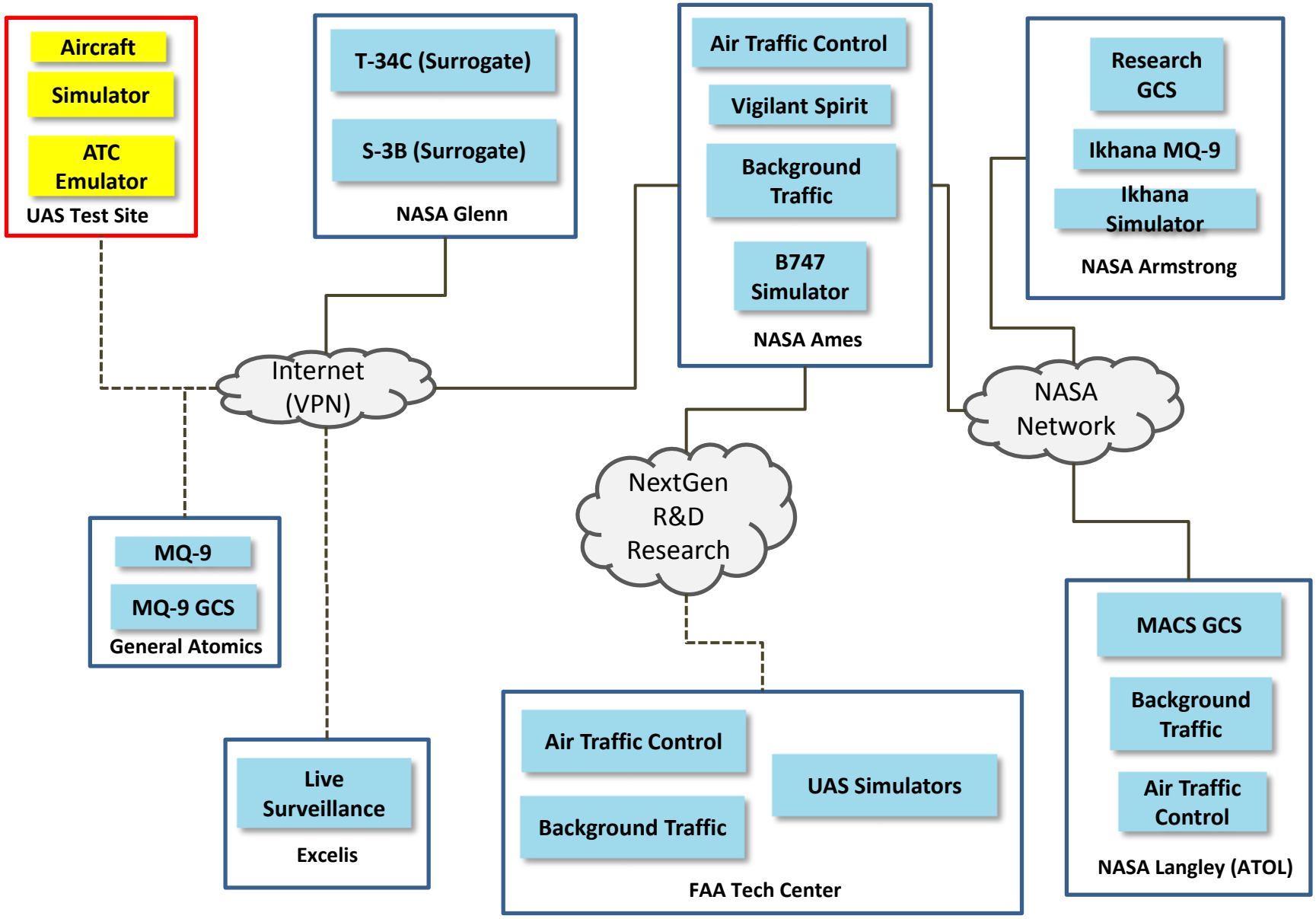
- Goal
  - Prototype LVC connection between UAS Test Sites and UAS Project Infrastructure for use in potential future DAA and other UAS research
- Purpose of this briefing: describe current and planned LVC usage
  - LVC Overview
  - Existing Connections
  - Planned Usage

LVC Conops

- Live: Real people operating real assets
- Virtual: Real people operating simulated assets
- Constructive: Simulated people operating simulated assets
- Distributed Environment: Brings simulation to the LVC assets increasing external partner options



High Level LVC Connectivity



LVC Assets

- Live
  - Ikhana (NASA's MQ-9)
  - T-34C (Surrogate UAS)
  - S-3B Viking (Surrogate UAS)
  - Vigilant Spirit Control Station
- Virtual
  - Ikhana Sim
  - B747 Flight Simulator
  - Vigilant Spirit Control Station
  - Multi-Aircraft Control System (MACS) ATC Emulator
- Constructive
  - MACS Pseudo Pilot








Ikhana MQ-9 Predator B at NASA Armstrong

T-34C at NASA Glenn

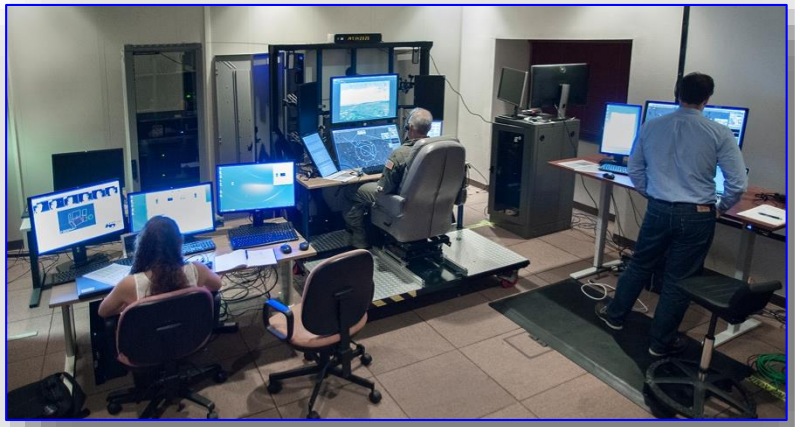
S-3B Viking at NASA Glenn

Ikhana Simulator at NASA Armstrong

B747 Flight Simulator at NASA Ames

UAS Ground Control Station at NASA Armstrong

Lab Layout for Flight Test



Pilot Control Station Layout for Flight Test

ATC and Pseudo Pilots at NASA Ames and NASA Langley

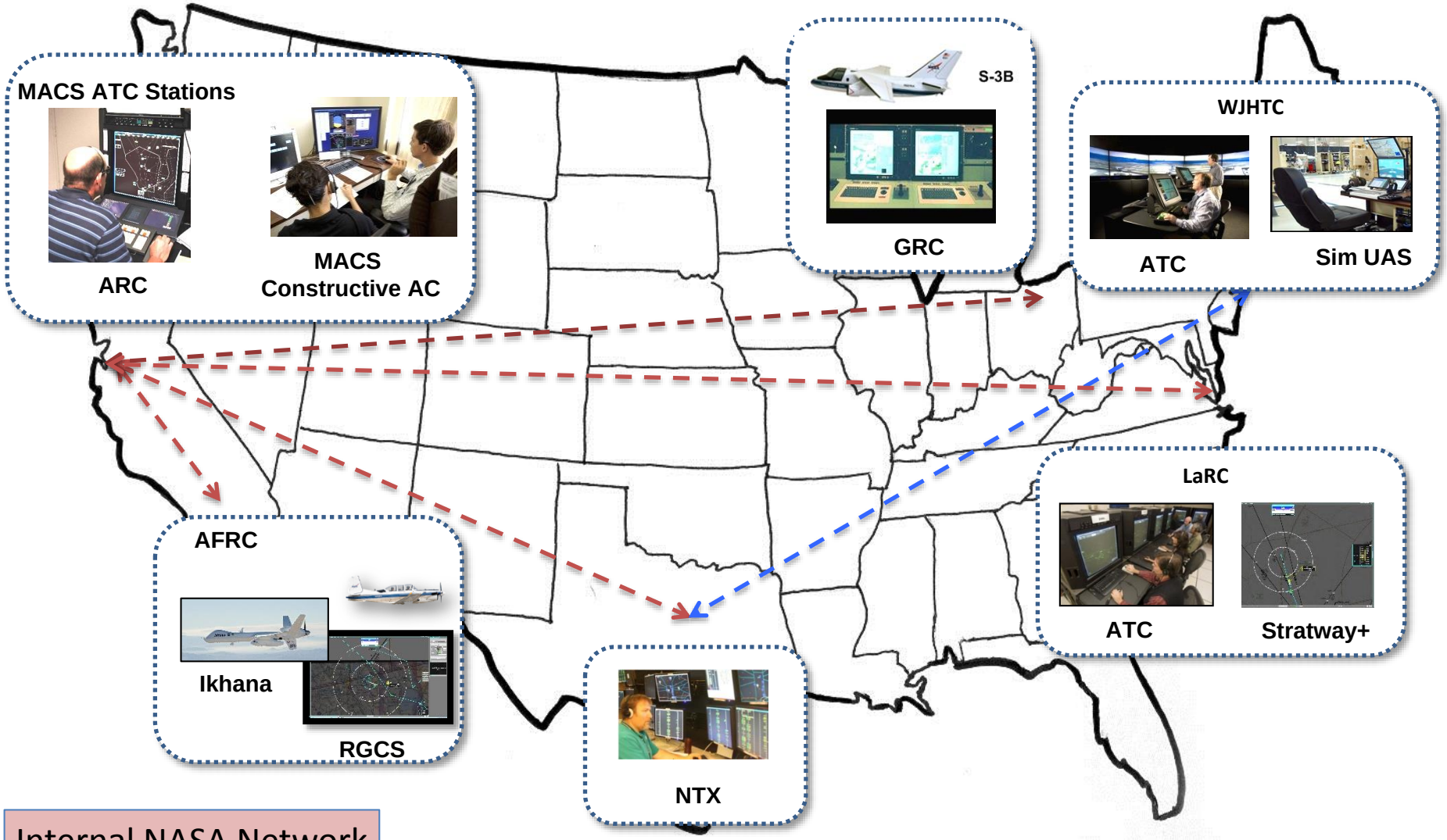
Pseudo Pilot Control

Air Traffic Control

Multi-Aircraft Control System (MACS)

Active/Ctrl AC List **Pseudo Pilot Control** **Air Traffic Control**

LVC Distributed Network



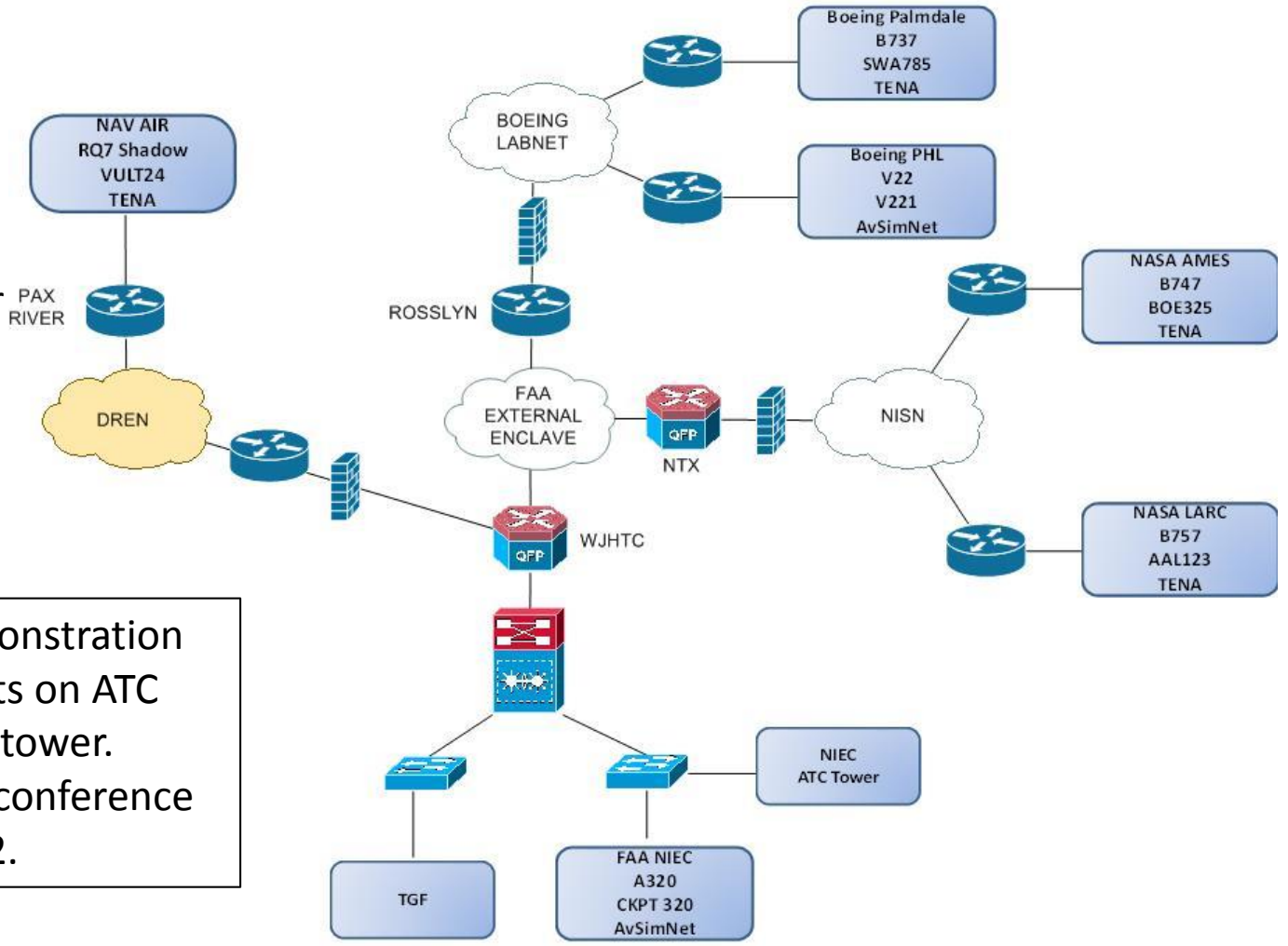
Internal NASA Network

External Network

Distributed Connectivity Demonstration

Initial test of distributed simulation capability among multiple participants

NASA Ames
NASA Langley
DoD NavAir Pax River
Boeing Palmdale
Boeing Philadelphia
FAA Technical Center

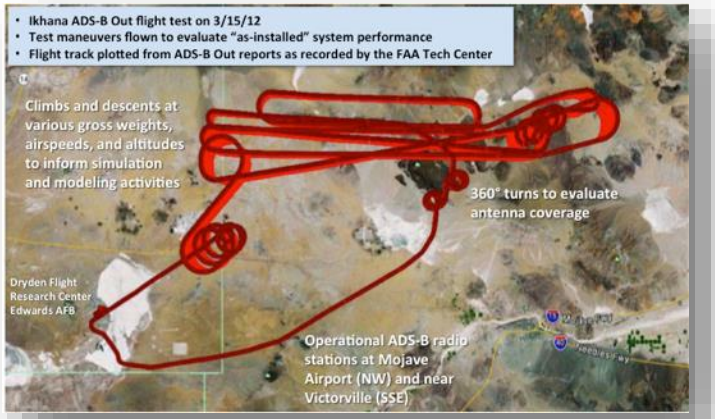


August 2012: Demonstration of simulated targets on ATC scopes and virtual tower. Presented at ITEA conference in September 2012.

Early Equipment Integration and Checkout

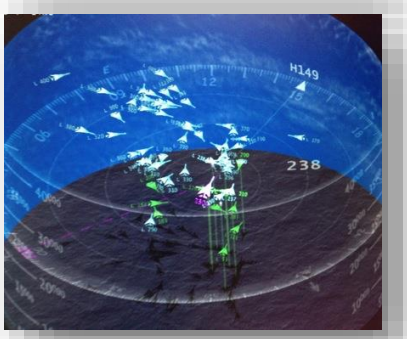
ADS-B Integration on the Ikhana UAS

- Integrated a COTS (Garmin GDL-90) ADS-B onto a large UAS
  - Full ADS-B Out and In functionality
  - Unprecedented traffic situational awareness to UAS pilots
- Collected ADS-B "as installed" performance flight test data
  - Accuracy, uncertainty of position, velocity, and altitude reports
  - ADS-B Out (Mar 15/20), ADS-B In (May 8/11)
- Flight test results (Flight Test Series 1)
  - Verified ADS-B Out met FAA Advisory Circular AC 20-165 for ADS-B Out equipage
  - Valuable FAA Tech Center support with validated data analysis tools
  - **Connected Dryden to LVC and Verified data exchange of live, virtual, and constructive traffic information between all participants**



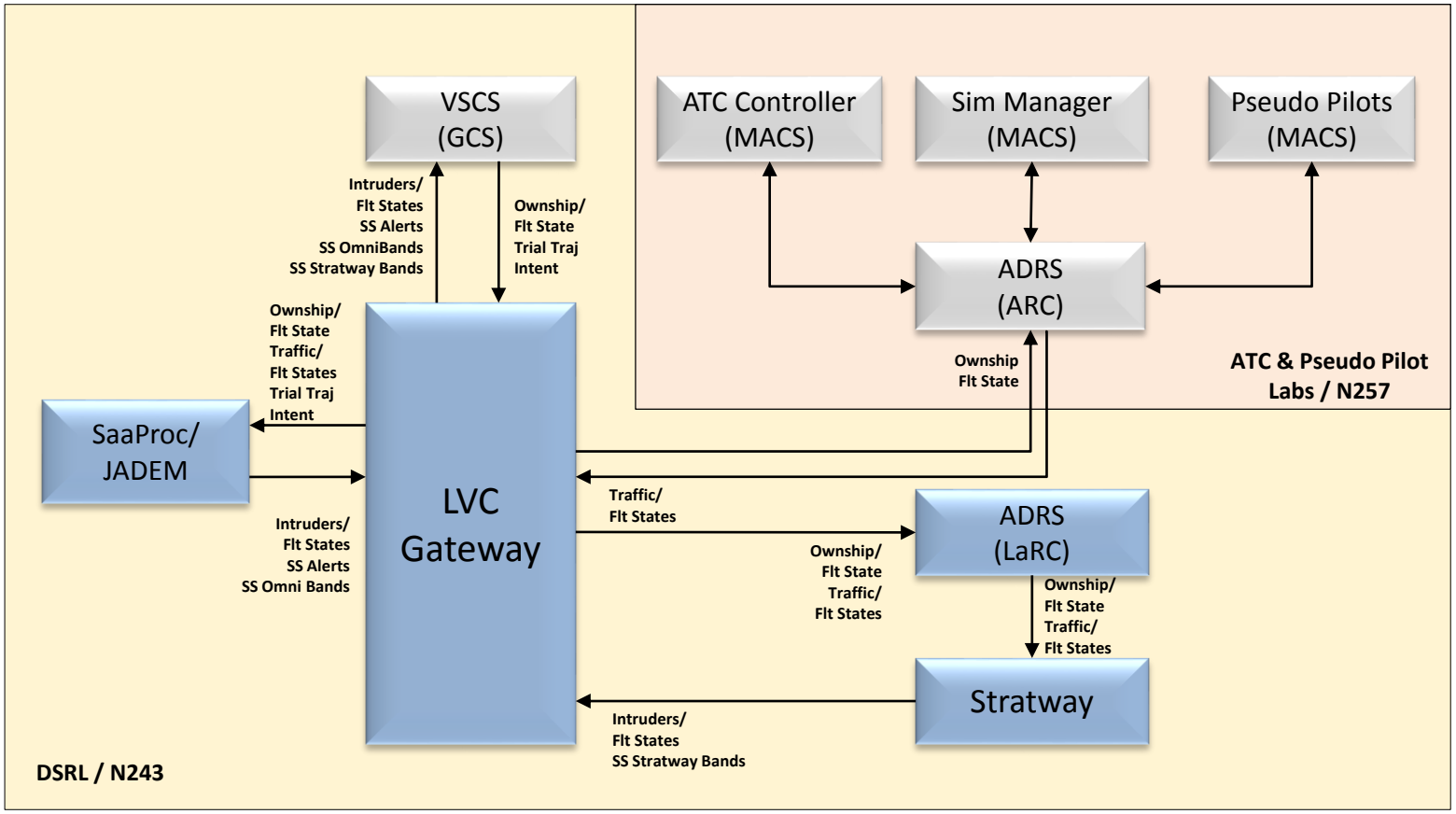
Ikhana flight path as tracked by the national ITT ADS-B Surveillance Network

ADS-B Ground Tests on Ikhana UAS

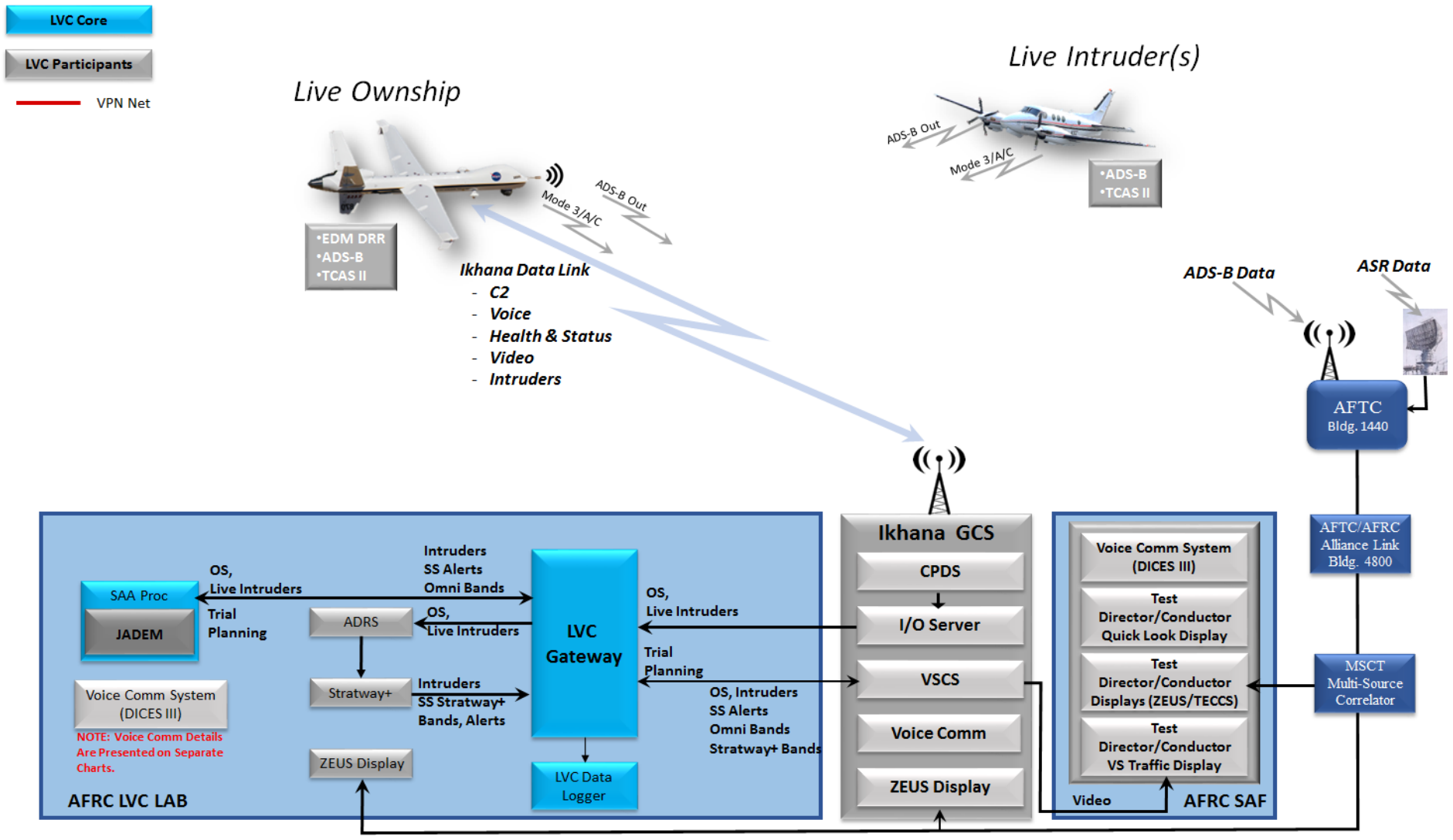


Live ADS-B and TIS-B data shown on virtual cockpit display

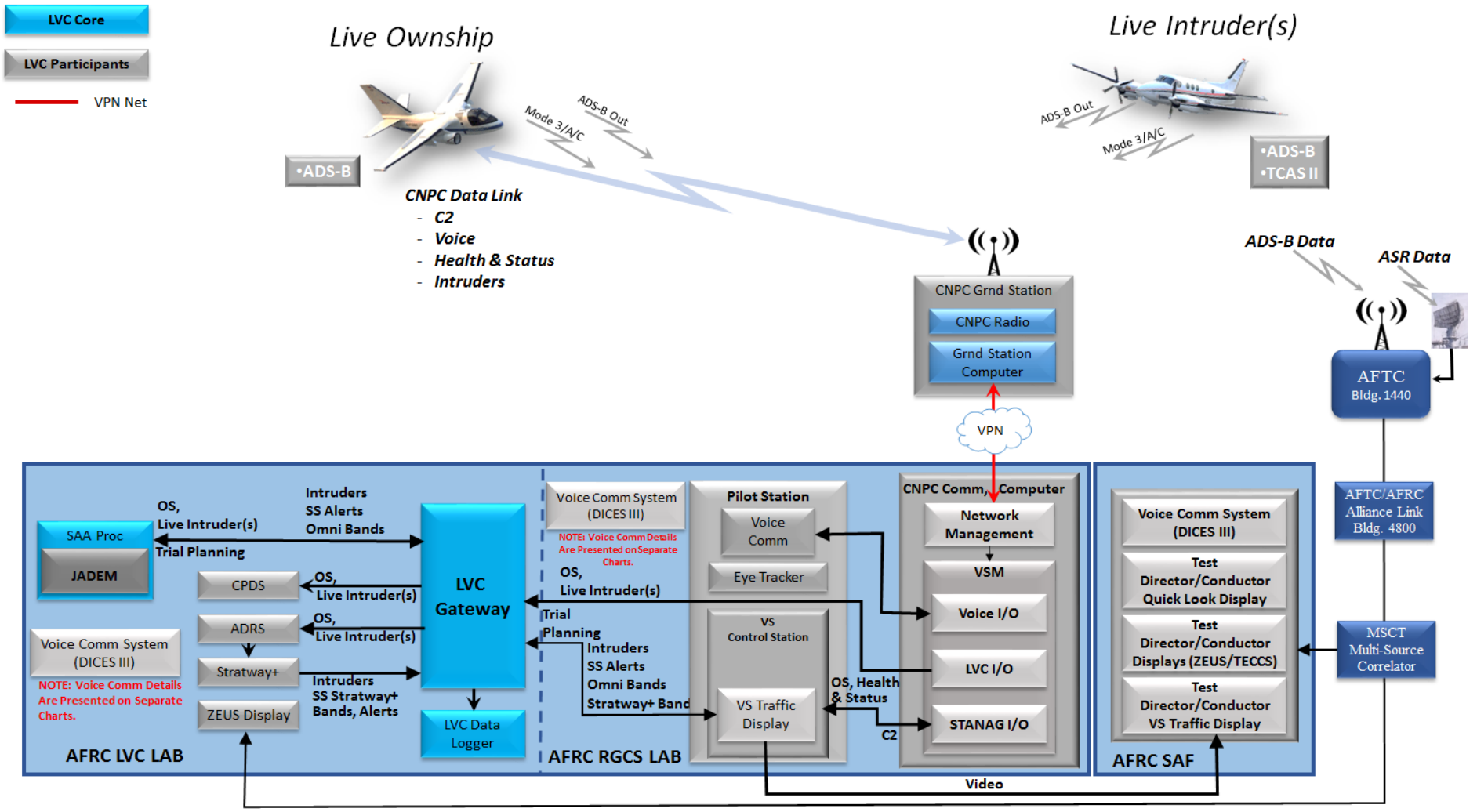
PT5 Experiment: High Level Architecture



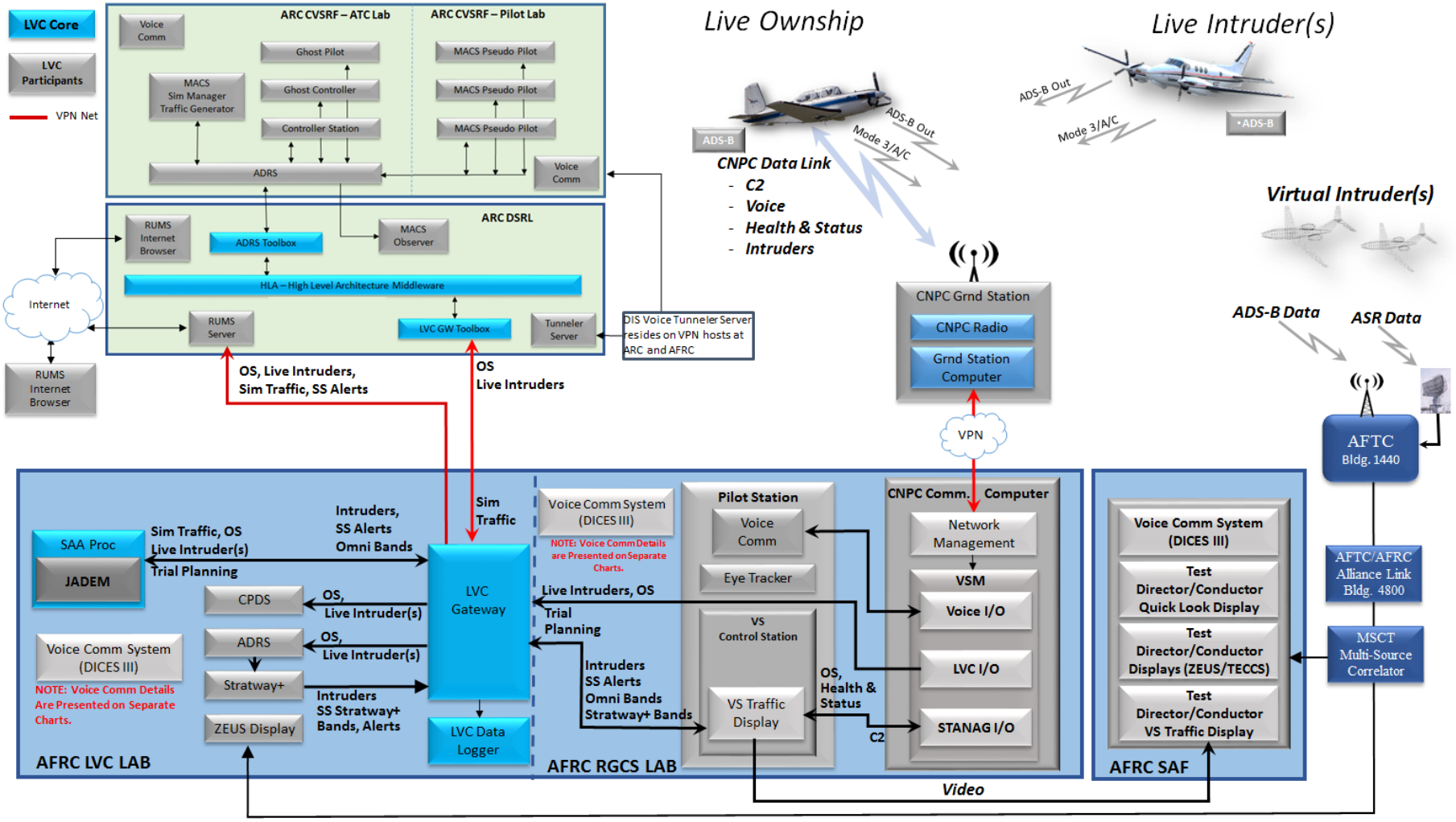
FT3: Configuration 1A (Pairwise-Low Speed Ownship) – Ikhana



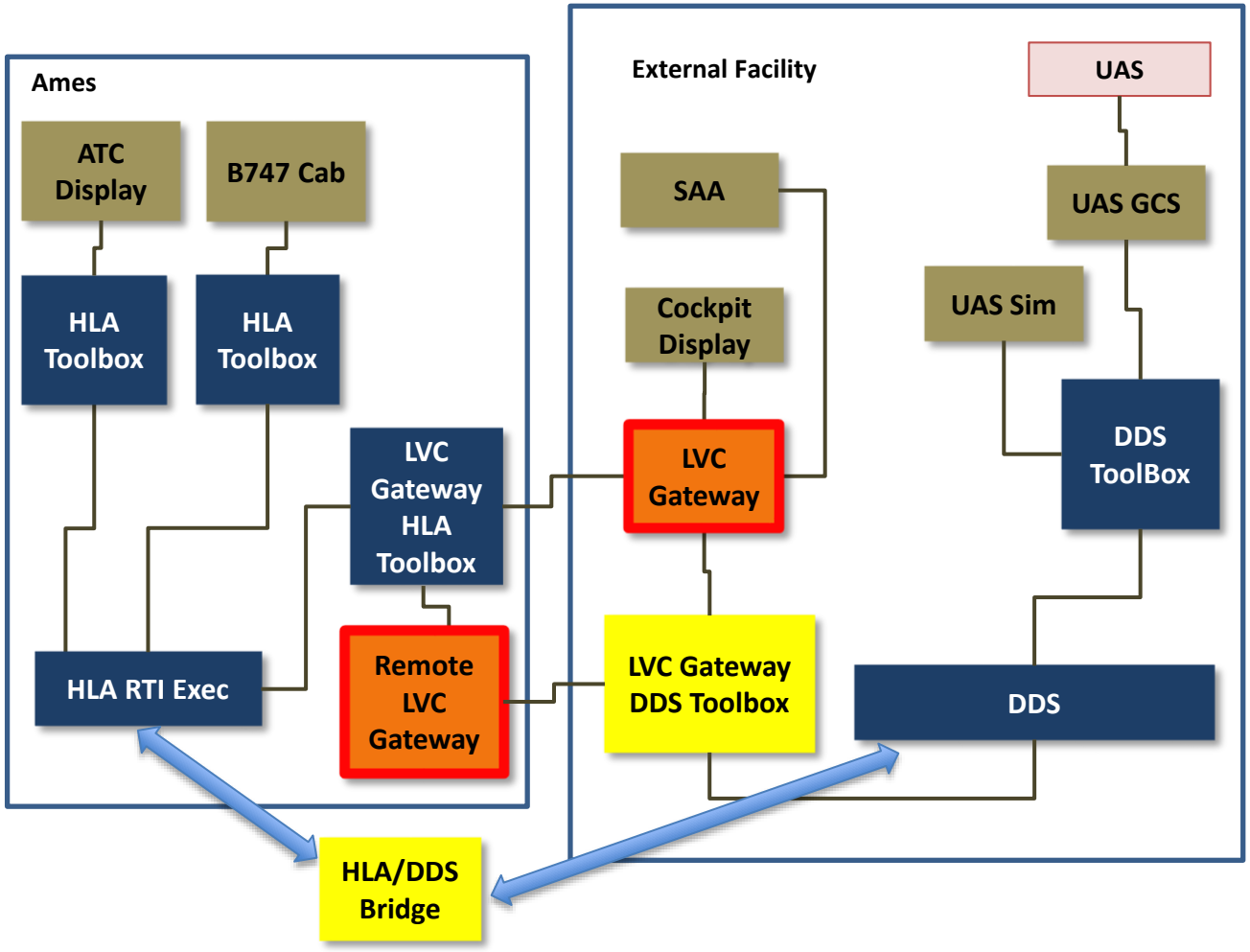
FT3: Configuration 1B (Pairwise-High Speed Ownship) – S-3B



FT3: Configuration – Surrogate UA



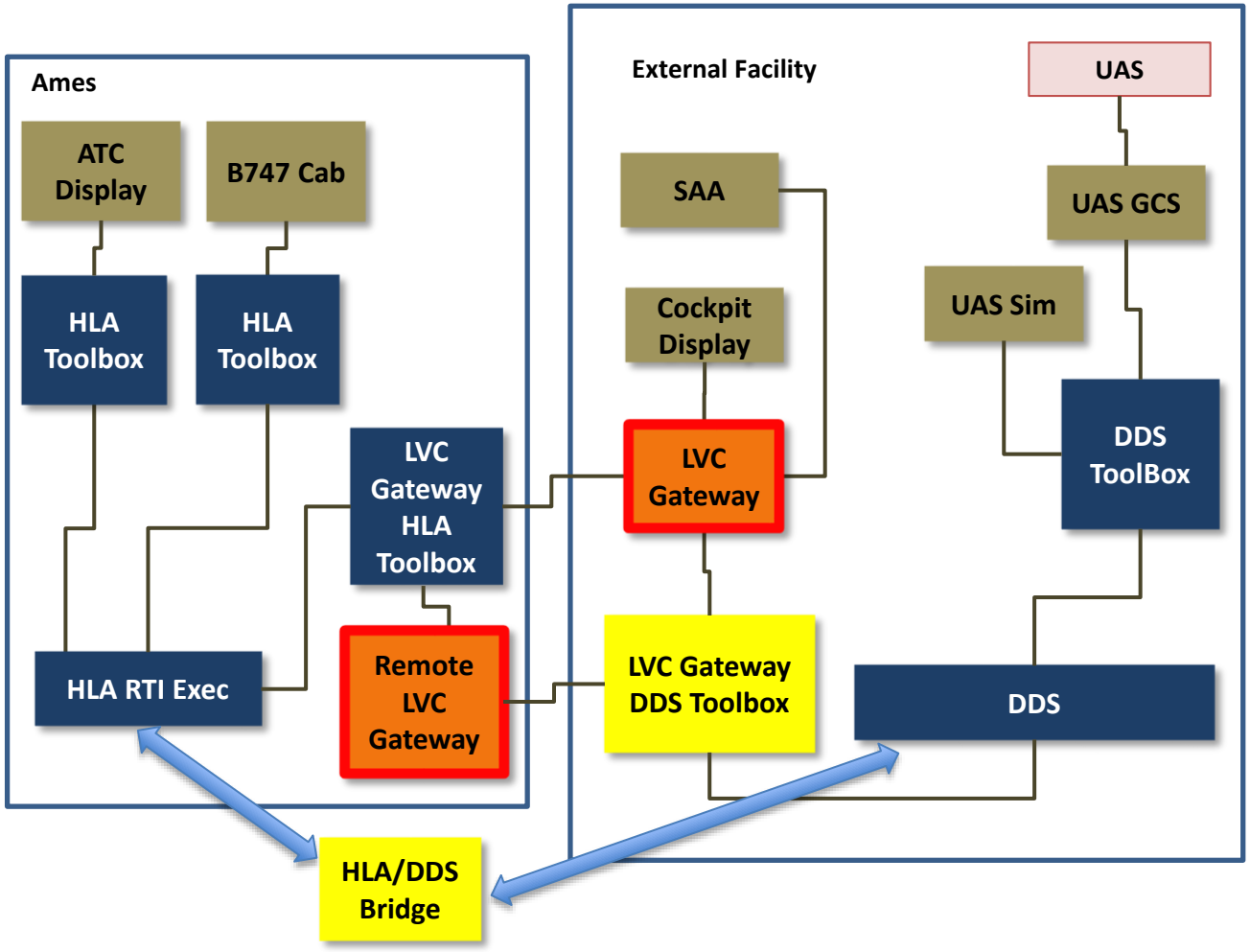
LVC Connection Options



Features:

- Local UAS LVC connection to demonstrate connectivity
- Leverages existing middleware infrastructure (DDS)
- Supports integration of existing UAS technologies
- Option 1: External connection through UAS LVC infrastructure
- Option 2: External connection via DDS/HLA Bridge

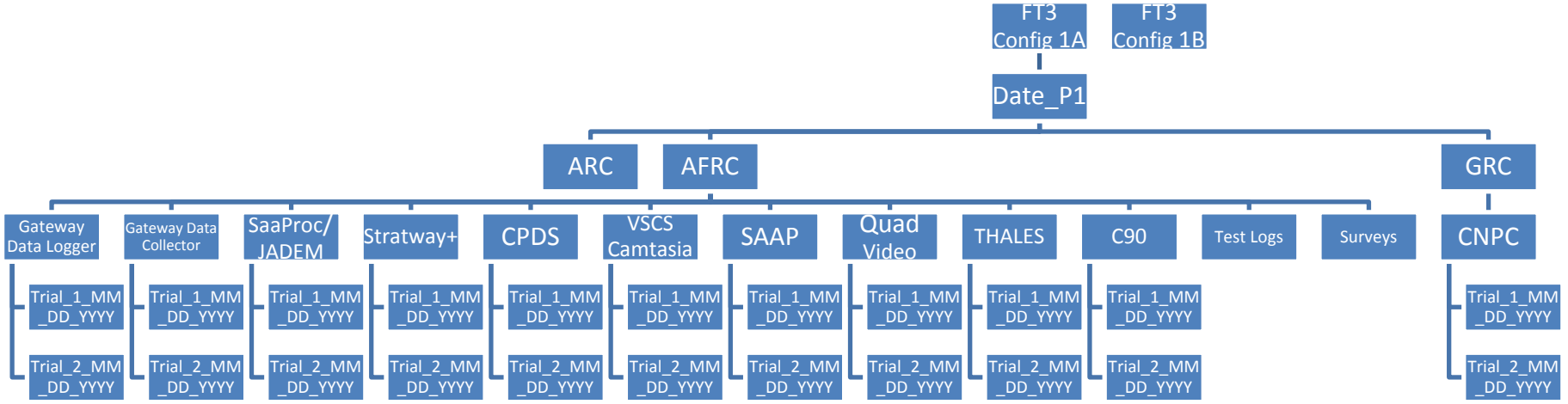
LVC Connection Options



Data Collection:

- LVC Gateway records all messages
- Can repeat LVC Gateways to collect data remotely

Example Data Archive Directory Structure



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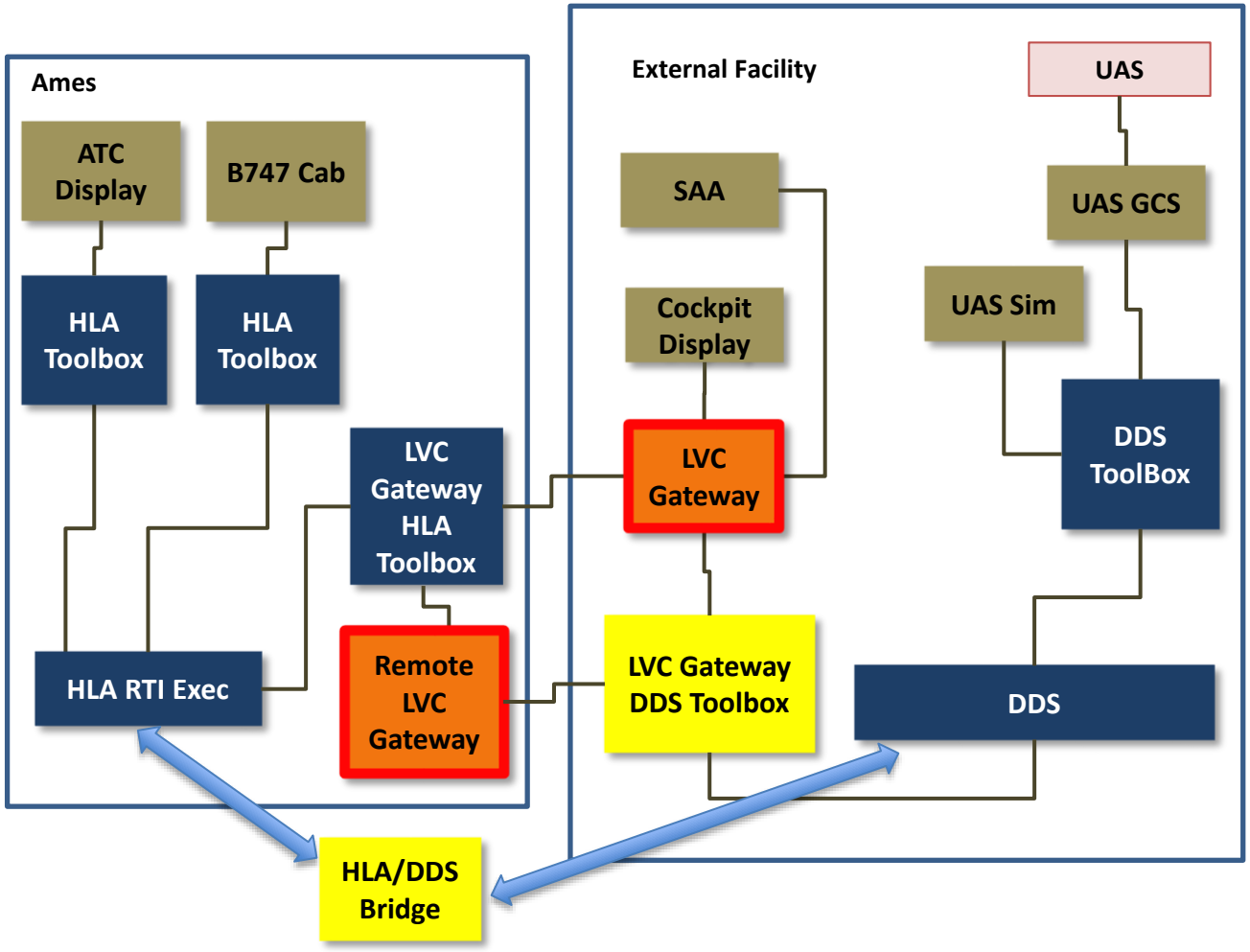
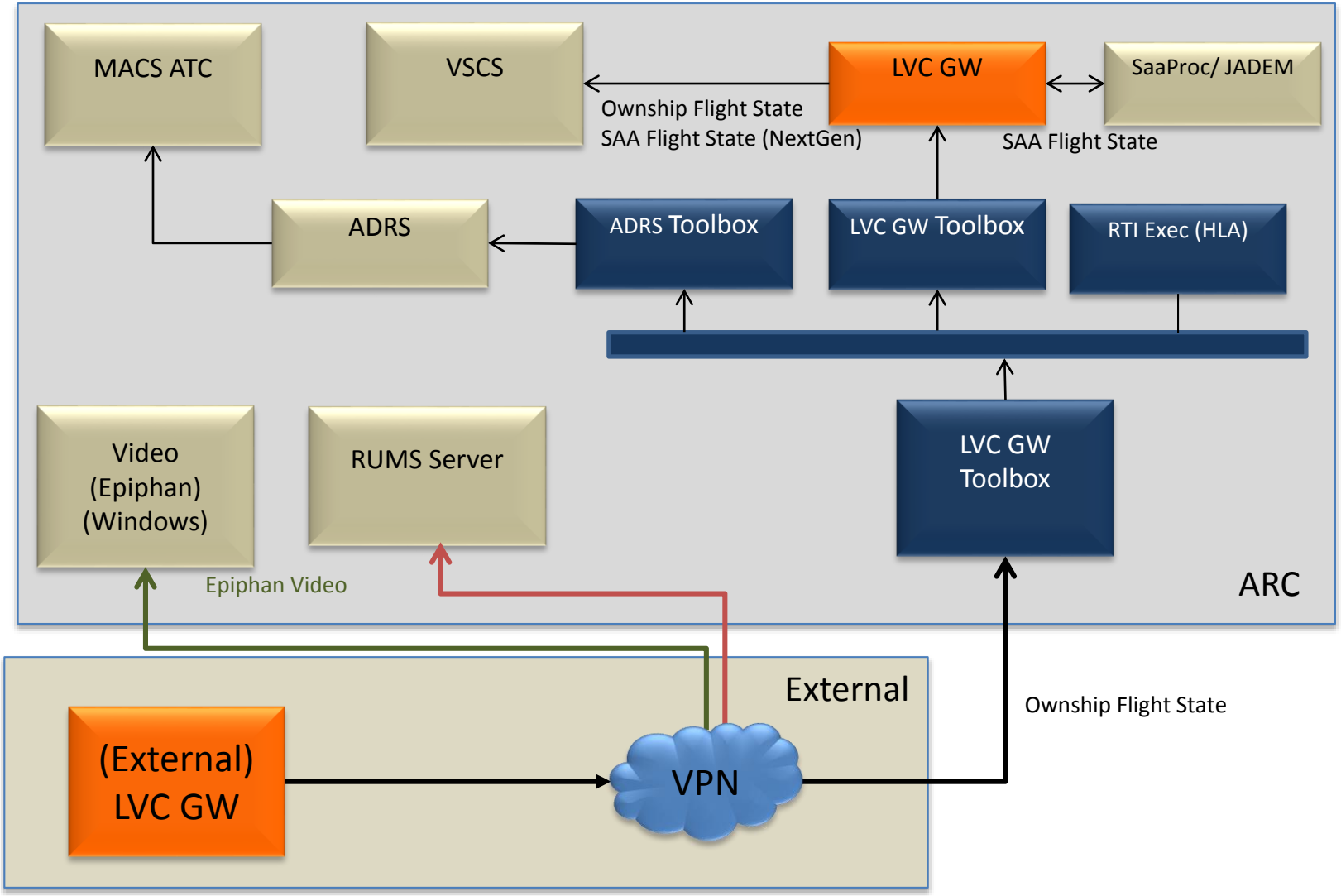


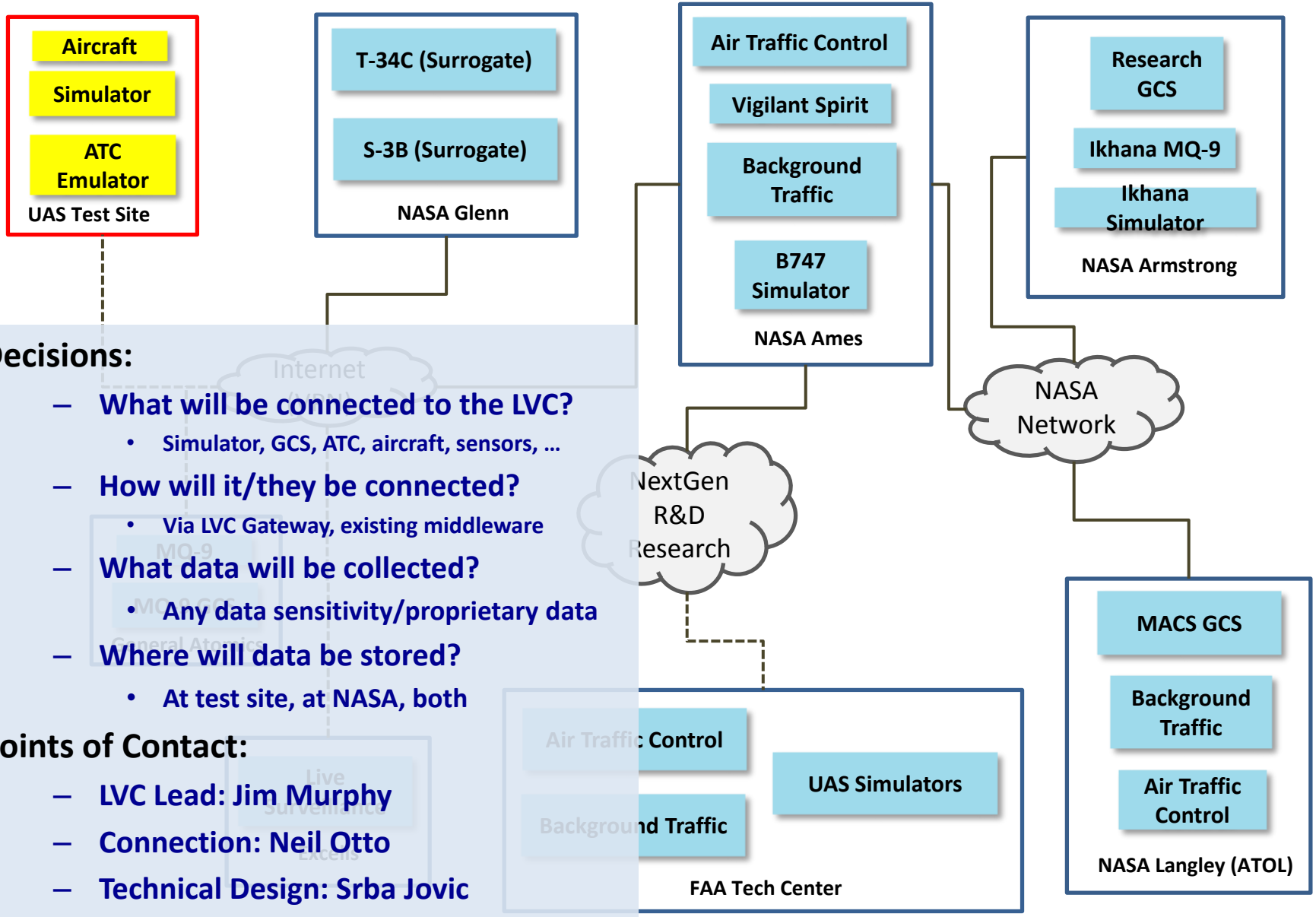
Data Connection:

- **Data Connection Agreement required**
  - Specifies machines and content of connection
  - Depends on connection design
- **Encrypted via VPN between UAS Test Site facility and NASA Ames SimLabs**

Alternative Connection



LVC Connectivity Decisions



Decisions:

- **What will be connected to the LVC?**
  - Simulator, GCS, ATC, aircraft, sensors, …
- **How will it/they be connected?**
  - Via LVC Gateway, existing middleware
- **What data will be collected?**
  - Any data sensitivity/proprietary data
- **Where will data be stored?**
  - At test site, at NASA, both

Points of Contact:

- **LVC Lead: Jim Murphy**
- **Connection: Neil Otto**
- **Technical Design: Srba Jovic**